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Land-Cover Change in the East Central Texas Plains, 1973–2000

Open-File Report 2009–1164

U.S. Department of the Interior
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Cover photograph. Plowed agricultural field near Bee and Live Oak counties, Texas (U.S. Geological Survey, 2006).

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By Krista A. Karstensen

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Conversion Factors

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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Project Background

The Geographic Analysis and Monitoring (GAM) Program of the U.S. Geological Survey (USGS) Land Cover Trends project is focused on understanding the rates, trends, causes, and consequences of contemporary U.S. land-use and land-cover change. The objectives of the study are to: (1) develop a comprehensive methodology for using sampling and change analysis techniques and Landsat Multispectral Scanner (MSS) and Thematic Mapper (TM) data for measuring regional land-cover change across the United States, (2) characterize the types, rates and temporal variability of change for a 30-year period, (3) document regional driving forces and consequences of change, and (4) prepare a national synthesis of land-cover change (Loveland and others, 1999).

Using the 1999 Environmental Protection Agency (EPA) Level III ecoregions derived from Omernik (1987) as the geographic framework, geospatial data collected between 1973 and 2000 were processed and analyzed to characterize ecosystem responses to land-use changes. The 27-year study period was divided into five temporal periods: 1973–1980, 1980–1986, 1986–1992, 1992–2000, and 1973–2000. General land-cover classes such as water, developed, grassland/shrubland, and agriculture for these periods were interpreted from Landsat MSS, TM, and Enhanced Thematic Mapper Plus imagery to categorize land-cover change and evaluate using a modified Anderson Land-Use Land-Cover Classification System for image interpretation. The interpretation of these land-cover classes complement the program objective of looking at land-use change with cover serving as a surrogate for land use.

The land-cover change rates are estimated using a stratified, random sampling of 10-kilometer (km) by 10-km blocks allocated within each ecoregion. For each sample block, satellite images are used to interpret land-cover change for the five time periods previously mentioned. Additionally, historical aerial photographs from similar timeframes and other ancillary data such as census statistics and published literature are used. The sample block data are then incorporated into statistical analyses to generate an overall change matrix for the ecoregion. For example, the scalar statistics can show the spatial extent of change per cover type with time, as well as the land-cover transformations from one land-cover type to another type occurring with time.

Field data of the sample blocks include direct measurements of land cover, particularly ground-survey data collected for training and validation of image classifications (Loveland and others, 2002). The field experience allows for additional observations of the character and condition of the landscape, assistance in sample block interpretation, ground truthing of Landsat imagery, and helps determine the driving forces of change identified in an ecoregion. Management and maintenance of field data, beyond initial use for training and validation of image classifications, is important as improved methods for image classification are developed, and as present-day data become part of the historical legacy for which studies of land-cover change in the future will depend (Loveland and others, 2002).

The results illustrate that there is no single profile of land-cover change; instead, there is significant geographic variability that results from land uses within ecoregions continuously adapting to the resource potential created by various environmental, technological, and socioeconomic factors.

The East Central Texas Plains

The East Central Texas Plains ecoregion encompasses 44,076 square kilometers (km^2) across east central Texas (fig. 1). Just south of the Oklahoma border on the north, the ecoregion extends to just south of the San Antonio River. The ecoregion includes the confluences of the Sulphur, Trinity, Navasota, Brazos, Colorado, Guadalupe Rivers, their tributaries, Lakes Tawakoni and Fork, and Richland Chambers, Somerville, and Cedar Creek Reservoirs. Located in the central part of the ecoregion, Bryan and College Station, Texas, are two of the larger cities and housed a census population of 152, 415 in April 2000 which was an increase of 25.1 percent since 1990 (U.S. Census Bureau, 2001).

The topography is categorized by irregular plains with acidic soils along the parallel ridges and valleys, sandy and sandy loam soils on the uplands, and clay and clay loams occupy the low-lying areas (Griffith and others, 2004). Elevation increases gradually from southeast to northwest. Additionally, many areas in this ecoregion are underlain with clay pan which affects water movement and availability for plant growth (Griffith and others, 2004). The overall annual

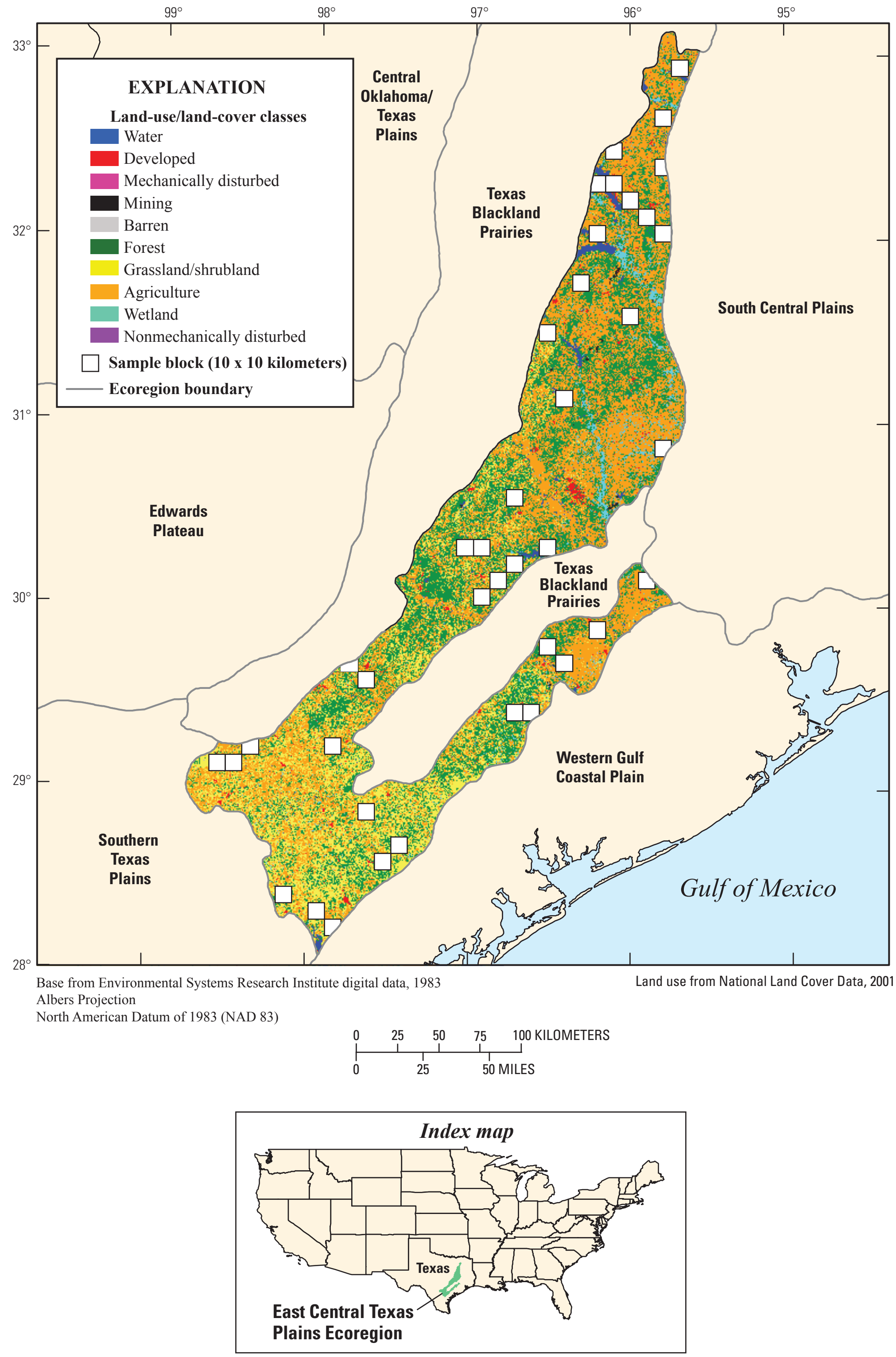

Figure 1. The East Central Texas Plains.

precipitation in this ecoregion is approximately 102 centimeters (cm) (Texas Parks and Wildlife Department, 2008). More specifically, the annual precipitation ranges from 102 to 122 cm in the part of the ecoregion north of the Cedar Creek Reservoir, and ranges from 71 to 102 cm south of the Trinity River.

Historically, fire and burning in the northern part of the ecoregion played an essential role in maintaining grassy openings. In the absence of fire, woody invasions have taken place (Griffith and others, 2004). Mixed native or introduced grasses and forbs on grassland sites or mixed herbaceous communities have resulted from the recent clearing of woody vegetation (Texas Parks and Wildlife Department, 2008). The deciduous forest in the East Central Texas Plains is made up of mostly post oak and blackjack oak. The post oak forests are particularly prevalent on the sandy soils of the ecoregion and primarily exist north of College Station (Yantis, 1984; Amy Hays, Texas A&M University, oral commun., 2009). The south central part of the ecoregion bordering the Colorado River has the westernmost tract of southern pine in the United States; cross timbers and blackland prairie also are common in the southern part of the ecoregion (Griffith and others, 2004; Amy Hays, Texas A&M University, oral commun., 2009).

Summary of Land-Use Change in the Ecoregion

Overall Spatial Change

The footprint of change in the ecoregion, the percentage of area that changed at least one time from 1973–2000, was 12.1 percent (+/- 1.8 percent); (table 1). The overall spatial change in the East Central Texas Plains was high when compared with other ecoregions in the Great Plains, and was similar to the ecoregions' immediate geographic neighbors, the Texas Blackland Prairies and Southern Texas Plains at 11.1 percent (+/- 2.6 percent) and 11.9 percent (+/- 2.5 percent), respectively. Of the ecoregions in the Great Plains, only the Northwest Glaciated Plains had a greater percent (13.6, +/- 2.2) of overall spatial change than the East Central Texas Plains. An estimated 10.4 percent (+/- 1.5 percent) of the ecoregion changed only one time, whereas 1.5 percent (+/- 0.3 percent) and 0.2 percent (+/- 0.1 percent) changed two and three times, respectively, during the 30-year study period.

Normalized Annual Rates of Change

When normalized to account for varying time period lengths, annual rates of change steadily increased during the first three time intervals reaching 0.7 percent per year from 1986 to 1992. These rates declined to 0.4 percent per year from 1992 to 2000 (table 2). Overall, these changes were slightly lower than those of the Texas Blackland Prairie and moderately higher than the Southern Texas Plains.

Land-Cover Composition and Net Change

Despite an overall net decrease of 2.9 percent, at the end of the study period agricultural land covered 43.5 percent (+/- 4.4 percent) of the ecoregion in 2000 (table 3, at the back of the report). Forested land was the second leading land-cover class at 30.4 percent (+/- 3.7 percent) despite an overall net decrease of 1.9 percent since 1973. Grassland/shrubland accounted for 17.2 percent (+/- 3.6 percent) of the ecoregion in 2000 (fig. 2). Of all the land-cover classes in the East Central Texas Plains, grassland/shrubland had the highest overall net increase at 1.6 percent, and was the third highest land-cover class in the ecoregion in 2000.

Most Common Land-Cover Conversions

Between 1973 and 2000, the five most common land-cover conversions were: (1) agriculture to grassland/shrubland, (2) forest to agriculture, (3) grassland/shrubland to forest, (4) grassland/shrubland to agriculture, and (5) forest to grassland/shrubland (table 4, at the back of the report). Whereas conversions to developed land did not place in the top five leading land-cover conversions, the socioeconomic impacts that are associated with the net increase of 1.3 percent of developed area during the study period is important to note.

Table 1. Percentage of the East Central Texas Plains that experienced spatial change and associated error.

[+, plus; -, minus; %, percent]

Number of changes	Percent of ecoregion	Margin of error (+/- %)	Lower bound (%)	Upper bound (%)	Standard error (%)	Relative error (%)
1	10.4	1.5	8.9	12	1.1	10.1
2	1.5	.3	1.2	1.8	.2	15.2
3	.2	.1	.1	.2	0	24.3
4	0	0	0	0	0	39.3
Overall spatial change	12.1	1.8	10.3	13.9	1.2	10.2

Table 2. Raw estimates of percent change in the East Central Texas Plains computed for each of the four time periods and associated error at an 85-percent confidence level.

[%, percent; +, plus; -, minus; km², square kilometers]

Period	Total change (% of ecoregion)	Margin of error (+/- %)	Lower bound (%)	Upper bound (%)	Standard error (%)	Relative error (%)	Average rate (% per year)
1973–1980	2.5	0.5	2	2.9	0.3	12.3	0.4
1980–1986	3.5	.8	2.8	4.3	.5	14.6	.6
1986–1992	4.4	1.4	3	5.8	1.0	21.5	.7
1992–2000	3.5	.5	3	4	.3	9.7	.4

Period	Total change (km² of ecoregion)	Margin of error (+/- km²)	Lower bound (km²)	Upper bound (km²)	Standard error (km²)	Relative error (%)	Average rate (km² per year)
1973–1980	1,098	199	899	1,297	136	12.3	157
1980–1986	1,563	335	1,227	1,898	229	14.6	260
1986–1992	1,953	617	1,336	2,571	421	21.5	326
1992–2000	1,536	218	1,318	1,754	148	9.7	192

Figure 2. An example of grassland/shrubland seen in Bee and Live Oak counties (U.S. Geological Survey, 2006).

Discussion

The East Central Texas Plains are a mosaic of improved pasture, rangeland, and cropland (Griffith and others, 2004). Whereas the overall amount of agricultural land declined during the study period, it still accounts for the largest amount of land cover in the ecoregion. Since 1970, approximately 1,000 new farms and ranches have been established in Texas each year, even though the total area in farms and ranches has declined by almost 3 million acres during that time; a statewide trend that is apparent in the East Central Texas Plains (U.S. Department of Agriculture National Agricultural Statistics Service, 2009).

The ecoregion historically has been a mix of post oak/blackjack oak forest and savannah on sandy soils interspersed with mid and tall grass prairie on the heavier soil sites (C. Kowaleski, Texas Parks and Wildlife, written commun., 2009). Although much of this land originally was farmed, the sandier sites quickly lost their fertility (C. Kowaleski, Texas Parks and Wildlife, written commun., 2009). In the early 1970s, abandoned farmland promoted cattle densities to increase gradually (Yantis, 1984). During this decade, the average land ownership size increased as old farms were consolidated into ranches (Yantis, 1984). In 1974, the central part of the ecoregion had approximately 18 people, 104 cattle, and 11 hogs per square mile (Yantis, 1984). Starting in the 1980s, Cooperative Extension promoted the idea of converting native grasses to coastal bermuda grass tame pastures, which when limed and fertilized allowed increased stocking rates (1 cow/acre) than can be achieved on native ranges (fig. 3) (C. Kowaleski, Texas Parks and Wildlife, written commun., 2009). Although the land use in the 1980s was similar to that of the 1970s, continued increase in human population was bringing more “weekend ranchers” to the area, and the average size of landholdings was decreasing as land use was intensifying (Yantis, 1984).

The impact of population on land use in the latter part of the study period is correlated to changes in ownership and size (Wilkins and others, 2003). From 1992–2001, the most notable land-use trend was the conversion of native rangelands and croplands to nonnative “improved pastures” (Wilkins and others, 2003). Unlike the consolidation that occurred in the early 1970s, fragmentation of rural acreage became dominant in the 1990s as large properties were divided into smaller parcels (Wilkins and others, 2003). This may help to describe

Figure 3. Cattle in a pasture, Caldwell County (U.S. Geological Survey, 2006).

the leading land-cover change in this ecoregion—agriculture to grassland/shrubland. As the land becomes fragmented, the properties become too small for traditional farming and ranching purposes, so they no longer contribute as much to rural economies (Wilkins and others, 2003); therefore, although the land use may remain, in essence, agricultural, the decrease in productivity may spectrally reflect grassland/shrubland (fig. 4).

Figure 4. Ranchland in Goliad County (U.S. Geological Survey, 2006).

Moreover, land in the ecoregion has become increasingly valuable with the expanding population of the nearby metropolitan areas. In that sense, there is a trend in land moving from high-intensity (crop production) to low intensity (rangeland). This trend began around 1994 and as such, the land has become more marketable as it moves toward low intensity land use (Amy Hays, Texas A&M University, oral commun., 2009). It is important to make the clarification that these lands are not considered abandoned agriculture, the owners simply find more economic value in holding the land than cropping it (Amy Hays, Texas A&M University, oral commun., 2009). The land owners may engage in low intensity practices such as turning the fields to hay defining an agricultural land cover, but not an agricultural land use. Additionally, the switch from high intensity to low intensity, or tame pasture, also has allowed many of the former savannah areas to become heavily overgrown with a yaupon holly understory (C. Kowaleski, Texas Parks and Wildlife, written commun., 2009).

Agricultural land cover in this ecoregion also was affected by the Texas Wildlife Management and Appraisal act of 1996. In Texas, county taxation is regulated by land class (Amy Hays, Texas A&M, oral commun., 2009). In November 1995, Texas voters approved Proposition 11, which amended Article VIII, Section 1-d-1, of the Texas Constitution to permit productivity appraisal for land used to manage wildlife (Harris County Appraisal District, 2009). House Bill (H.B.) 1358 implemented the constitutional amendment by adding wildlife management as an agricultural use that qualifies the land for agricultural (productivity) appraisal in Property Tax Code Section 23.51 (HCAD, 2009). H.B. 1358 greatly increased the amount of land designated for wildlife management, which is another example of how agricultural land use could be spectrally designated as grassland/shrubland land cover, and may be a reason behind the overall net decrease in agricultural land cover and the overall net increase in grassland/shrubland land cover illustrated in table 3.

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Tables

Table 3. Estimated area for each land-cover class in the East Central Texas Plains between 1973 and 2000.

[%, percent; +, plus; -, minus; km², square kilometers]

	Water		Developed		Mechanically distrubed		Mining		Barren		Forest		Grass/shrub		Agriculture		Wetlands		Nonmechanically disturbed	
	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-	%	+/-
1973	2.6	1.3	1.8	0.5	0	0	0.2	0.1	0.1	0.1	32.3	4.0	15.6	3.6	46.4	4.7	1	0.3	0	0
1980	2.6	1.3	2.0	.6	0.1	0	.3	.2	.1	.1	32.0	3.9	16.0	3.6	46.0	4.6	1	.3	0	0
1986	3.1	1.4	2.3	.7	.1	0.1	.4	.2	.1	.1	31.7	3.8	16.1	3.5	45.4	4.5	1	.3	0	0
1992	4	1.7	2.8	.8	0	0	.4	.2	.1	.1	31.0	3.8	16.7	3.5	44.0	4.5	1.1	.3	0	0
2000	4	1.7	3.2	.9	.2	.2	.4	.2	0.1	.1	30.4	3.7	17.2	3.6	43.5	4.4	1.1	.3	0	0
Net change	1.3	1.3	1.3	.5	.2	.2	.2	.1	0	0	-1.9	1	1.6	.8	-2.9	1.3	.1	.1	0	0
Gross change	1.6	1.3	1.3	.5	.5	.3	.3	.2	0	0	3.8	.8	3.9	.6	5.3	1.1	.1	.1	0	0

	Water		Developed		Mechanically distrubed		Mining		Barren		Forest		Grass/shrub		Agriculture		Wetlands		Nonmechanically disturbed	
	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-	km²	+/-
1973	1,155	560	812	240	3	4	90	56	29	30	14,244	1,775	6,875	1,580	20,435	2,085	431	146	0	0
1980	1,157	559	901	270	29	21	117	79	30	30	14,085	1,704	7,059	1,570	20,264	2,035	434	145	0	0
1986	1,349	600	1,017	302	38	41	154	106	32	30	13,950	1,661	7,093	1,546	20,003	2,000	437	144	0	0
1992	1,756	758	1,227	369	21	18	158	108	31	30	13,653	1,674	7,352	1,558	19,413	1,974	464	145	0	0
2000	1,746	751	1,389	417	97	74	160	101	31	30	13,420	1,639	7,593	1,605	19,173	1,942	466	144	0	0
Net change	591	564	577	229	94	74	70	47	1	2	-824	439	718	363	-1,263	589	34	29	0	0
Gross change	686	563	577	229	227	113	119	73	6	5	1,666	338	1,719	270	2,327	468	62	42	0	0

Table 4. Leading land-cover conversions in the East Central Texas Plains during each of four time periods.

[km^2, square kilometers; +, plus; -, minus; n/a, not applicable]

Period	From class	To class	Area changed (km^2)	Margin of error (+/- km^2)	Standard error (km^2)	Percent of ecoregion	Percent of all changes
1973–1980	Agriculture	Grassland/shrubland	334	98	67	0.8	30.4
	Forest	Agriculture	197	86	58	.4	18
	Grassland/shrubland	Forest	107	48	32	.2	9.7
	Grassland/shrubland	Agriculture	87	36	25	.2	7.9
	Forest	Grassland/shrubland	81	35	24	.2	7.4
	Other	Other	292	n/a	n/a	.7	26.6
			1,098			2.5	100
1980–1986	Agriculture	Grassland/shrubland	369	116	79	.8	23.6
	Grassland/shrubland	Forest	196	68	47	.4	12.5
	Forest	Agriculture	187	48	33	.4	12
	Grassland/shrubland	Agriculture	150	56	38	.3	9.6
	Agriculture	Forest	114	54	36	.3	7.3
	Other	Other	547	n/a	n/a	1.2	35
			1,563			3.5	100
1986–1992	Agriculture	Grassland/shrubland	559	154	105	1.3	28.6
	Forest	Water	199	202	138	.5	10.2
	Grassland/shrubland	Agriculture	165	81	55	.4	8.5
	Agriculture	Water	148	199	135	.3	7.6
	Grassland/shrubland	Forest	144	51	34	.3	7.4
	Other	Other	737	n/a	n/a	1.7	37.7
			1,953			4.4	100
1992–2000	Agriculture	Grassland/shrubland	428	153	104	1	27.9
	Forest	Grassland/shrubland	162	83	56	.4	10.5
	Forest	Agriculture	159	50	34	.4	10.3
	Grassland/shrubland	Forest	152	38	26	.3	9.9
	Grassland/shrubland	Agriculture	147	51	35	.3	9.6
	Other	Other	488	n/a	n/a	1.1	31.7
			1,536			3.5	100
Overall							
1973–2000	Agriculture	Grassland/shrubland	1,691	339	231	231	27.5
	Forest	Agriculture	662	162	110	110	10.8
	Grassland/shrubland	Forest	600	163	111	111	9.7
	Grassland/shrubland	Agriculture	549	177	120	120	8.9
	Forest	Grassland/shrubland	432	167	114	114	7
	Other	Other	2,217	n/a	n/a	n/a	36.1
			6,150			140	100

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